Backgrounder

United States Nuclear Regulatory Commission
Office of Public Affairs
Washington, DC 20555
Telephone: 301/415-8200 E-mail: opa@nrc.gov

New Nuclear Plant Designs

Background

The NRC has long sought standardization of nuclear power plant designs, and the enhanced safety and licensing reform that standardization could make possible. The NRC's regulation (Part 52 to Title 10 of the Code of Federal Regulations) provides a predictable licensing process including certification of new nuclear plant designs. The design certification process provides for early public participation and resolution of safety issues prior to an application to construct a nuclear power plant.

Pre-Application Review Process

The NRC's "Statement of Policy for Regulation of Advanced Nuclear Power Plants," dated July 8, 1986, encourages early discussions, before a license application, between NRC and reactor designers to provide licensing guidance. In June 1988, the NRC issued NUREG-1226, "Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants." This document provides guidance on the implementation of the policy and describes the approach used by NRC in its review of advanced reactor design concepts.

The NRC conducts pre-application reviews of advanced reactor designs to identify:

- major safety issues that could require Commission policy guidance to the staff,
- major technical issues that the staff could resolve under existing regulations or NRC policy, and
- research needed to resolve identified issues.

Design Certification Review Process

The review process for new reactor designs involves the certification of standard reactor designs by rulemaking (Subpart B of Part 52). Design certification applicants must provide the technical information necessary to demonstrate compliance with the safety standards set forth in applicable NRC regulations (10 CFR Parts 20, 50, 73, and 100). Applicants must also provide information to close out unresolved and generic safety issues, as well as issues that arose after the Three Mile Island accident. The application must include a detailed analysis of the design's vulnerability to certain accidents or events, and inspections, tests, analyses, and acceptance criteria to verify the key design features.

Currently there are four certified reactor designs that can be referenced in an application for a combined license. They are:

1. **Advanced Boiling Water Reactor** design by GE Nuclear Energy (May 1997);
2. **System 80+** design by Westinghouse (formerly ABB-Combustion Engineering) (May 1997);
3. **AP600** design by Westinghouse (December 1999); and
4. **AP1000** design (pictured) by Westinghouse (February 2006).

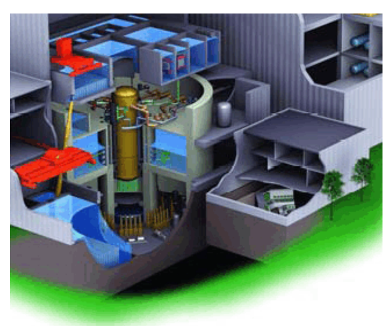
Regulatory Structure for New Plant Licensing

In the longer term, the NRC may be called on to review reactor designs that use a broader range of technology than those currently under review. Therefore, the NRC staff is developing technology-neutral guidelines for plant licensing in the future. These guidelines are intended to encourage future designs to incorporate additional safety and security where possible. The staff expects to complete this effort in 2007.

Reactor Design Review Status

The status of advanced reactor applications for both active and inactive design reviews is provided below in alphabetical order. A description of each design follows.

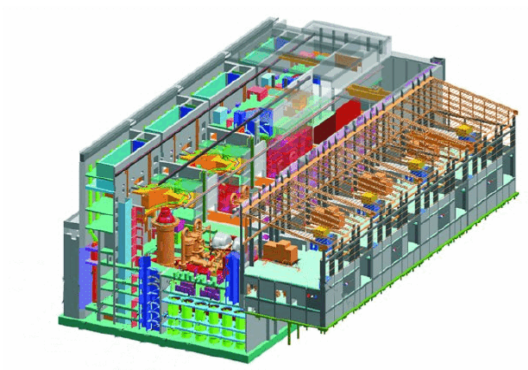
<u>Active Reviews</u>



• **<u>ESBWR</u>** - General Electric requested pre-application review of its design in a letter to the NRC dated April 18, 2002. General Electric submitted its design certification application for the ESBWR on August 24, 2005. The staff accepted the application for review in a letter dated December 1, 2005, and expects the certification process to continue through 2010.

• **<u>EPR</u> -** Areva NP has initiated pre-application discussions with the NRC staff, outlining its plans in a February 8, 2005, letter. Framatome expects to submit a design certification application in late 2007.

. **PBMR (pictured)-** A South African firm, Pebble Bed Modular Reactor (PBMR) Pty. Limited notified the NRC in a letter dated February 18, 2004, that it intended to apply for design certification in the near future and requested discussions with the NRC to plan the scope and content of the preapplication review. NRC staff have held several public meetings with PBMR to discuss its activities and plans to submit pre-application information. PBMR has continued to submit pre-application information through 2006 and expects to submit a design certification application in 2008.



. **US-APWR -** Mitsubishi Heavy Industries (MHI), a Japanese firm, met with NRC staff in July 2006 to discuss its intent to apply for design certification for the U.S.-specific version of its Advanced Pressurized Water Reactor, an evolutionary design being licensed and built in Japan. MHI expects to submit a design certification application early in 2008.

Inactive Reviews

• **IRIS** - In May 2006, Westinghouse and the NRC staff discussed the current status of the International Reactor Innovative and Secure (IRIS). The planned submittal of a design certification application for IRIS has been changed from 2008 to 2010. Westinghouse plans to submit topical reports in 2006 and 2007 related to the planned test programs in support of preapplication interactions. Westinghouse cited international interest in the design and involvement with the Global Nuclear Energy Partnership.

• **Toshiba 4S** - On February 2, 2005, the NRC staff met with the City Manager and Vice Mayor of Galena, Alaska to discuss and answer questions on the city's plans to build a Toshiba 4S reactor to provide its electricity. To date, Toshiba has not contacted the NRC regarding possible licensing of the 4S.

• **HT3R -** On May 11, 2006, the NRC staff held an initial public meeting with the University of Texas and General Atomics (GA) to discuss the potential licensing of a High-Temperature Teaching and Test Reactor at the University of Texas of the Permian Basin (UTPB) campus. UTPB has indicated that its preliminary plans include submitting a license application in early 2009, starting construction in early 2010, and completing construction and licensing by the end of 2012. NRC staff are working with UTPB and GA to support planning during the remainder of the HT3R pre-conceptual design phase in 2006 and to review the licensing plan developed during the conceptual design phase in 2007.

Design Descriptions

ABWR: The U.S. Advanced Boiling Water Reactor design uses a single-cycle, forced circulation, reactor with a rated power of 1,300 megawatts electric (MWe). The design incorporates features of the BWR designs in Europe, Japan, and the United States, and uses improved electronics, computer, turbine, and fuel technology. The design is expected to increase plant availability, operating capacity, safety, and reliability. Improvements include the use of internal recirculation pumps, control rod drives that can be controlled by a screw mechanism rather than a step process, microprocessor-based digital control and logic systems, and digital safety systems. The design also includes safety enhancements such as protection against overpressurizing the containment, passive core debris flooding capability, an independent water makeup system, three emergency diesels, and a combustion turbine as an alternate power source.

AP600: This is a 600 MWe advanced pressurized water reactor that incorporates passive safety systems and simplified system designs. The passive systems use natural driving forces without active pumps, diesels, and other support systems after actuation. Use of redundant, non-safety-related, active equipment and systems minimizes unnecessary use of safety-related systems.

AP1000: This is a larger version of the previously approved AP600 design. It is a 1,000 MWe advanced pressurized water reactor that incorporates passive safety systems and simplified system designs. It is similar to the AP600 design but uses a longer reactor vessel to accommodate longer fuel, and also includes larger steam generators and a larger pressurizer.

EPR (pictured): The EPR is a large pressurized water reactor of evolutionary design, with design output of approximately 1,600 MWe. Design features include four 100% capacity trains of engineered safety features, a double-walled containment, and a “core catcher” for containment and cooling of core materials for severe accidents resulting in reactor vessel failure. The design does not rely on passive safety features. The first EPR is currently being constructed at the Olkiluoto site in Finland. Framatome also hopes to build EPR’s at the Flammanville site in France, and has submitted a bid for EPR construction in China.

ESBWR: The Economic and Simplified Boiling Water Reactor (ESBWR) is a 1,390 MWe, natural circulation boiling water reactor that incorporates passive safety features. This design is based on its predecessor, the 670 MWe Simplified BWR (SBWR) and also utilizes features of the certified Advanced Boiling Water Reactor (ABWR). Natural circulation was enhanced in the ESBWR by using a taller vessel, a shorter core, and by reducing the flow restrictions. The ESBWR design utilizes the isolation condenser system for high-pressure water level control and decay heat removal during isolated conditions. After the automatic depressurization system operates, low-pressure water level control is provided by the gravity-driven cooling system. Containment cooling is provided by the passive containment cooling system.

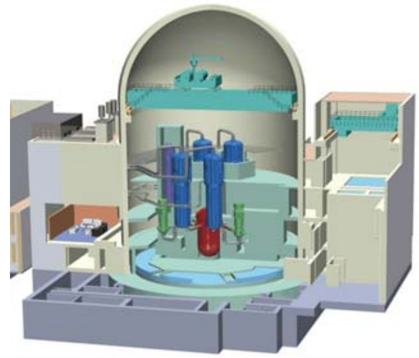
HT3R: The High-Temperature Teaching and Test Reactor would be a small high-temperature, gas-cooled reactor (HTGR) with prismatic graphite fuel blocks, 10 percent enriched uraniumoxide coated particle fuel, a power output of 25 thermal megawatts (MWt), and a helium coolant outlet temperature of 850 ˚C (1562 ˚F). The passive safety characteristics of the HT3R would be similar to those of proposed commercial modular HTGR designs such as the PBMR. The HT3R would potentially be used for testing and demonstrating HTGR technology and its application to Brayton cycle electric power generation, hydrogen production, water desalination, and other uses of high-temperature process heat. The reactor would also support isotope production, basic research, teaching, and operator training.

IRIS: The International Reactor Innovative and Secure is a pressurized light water cooled, medium-power (1,000 MWt) reactor that has been under development for several years by an international consortium. IRIS is a pressurized water reactor that utilizes an integral reactor coolant system layout. The IRIS reactor vessel houses not only the nuclear fuel and control rods, but also all the major reactor coolant systems components including pumps, steam generators, pressurizer and neutron reflector. The IRIS integral vessel is larger than a traditional PWR pressure vessel, but the size of the IRIS containment is a fraction of the size of corresponding loop reactors.

PBMR: The Pebble Bed Modular Reactor is a modular HTGR that uses helium as its coolant. PBMR design consists of eight reactor modules, 165 MWe per module, with capacity to store 10 years of spent fuel in the plant (there is additional storage capability in onsite concrete silos). The PBMR core is based on the German high-temperature gas-cooled reactor technology and uses spherical graphite elements containing ceramic-coated fuel particles.

System 80+: This standard plant design uses a 1,300 MWe pressurized water reactor. It is based upon evolutionary improvements to the standard CE System 80 nuclear steam supply system and a balance-of-plant design developed by Duke Power Co. The System 80+ design has safety systems that provide emergency core cooling, feedwater and decay heat removal. The new design also has a safety depressurization system for the reactor, a combustion turbine as an alternate AC power source, and an in-containment refueling water storage tank to enhance the safety and reliability of the reactor system.

Toshiba 4S: The Toshiba 4S reactor design has an output of about 10 MWe (approximately 30 MWt). The reactor has a compact core design, with steel-clad metal-alloy fuel. The core design does not require refueling over the 30-year lifetime of the plant. A three-loop configuration is used: primary system (sodium-cooled), an intermediate sodium loop between the radioactive primary system and the steam generators, and the water loop used to generate steam for the turbine. The basic layout is a “pool” configuration, with the pumps and intermediate heat exchanger inside the primary vessel.



US-APWR: The Mitsubishi Heavy Industry US-APWR design is an evolutionary 1,700 MWe pressurized water reactor currently being licensed and built in Japan. The design includes high-performance steam generators, a neutron reflector around the core to increase fuel economy, redundant core cooling systems and refueling water storage inside the containment building, and fully digital instrumentation and control systems.

August 2006